Report Tips

How to max your points

What should be included (Working Notes)

- What you are doing in this lab
- Brief details of every step (should follow your entire process)
- Photos (show me what you did)
- Document your issues, troubleshooting, and solution
- Anything required by the assignment
- Conclusion/Findings

What should be included (Excel/Data Sheet)

- Anything numerical
- Plots, graphs, etc.
- EVEN IF YOU PUT IT IN THE WORKING NOTES, PUT IT HERE ALSO

Final Tips

- Make the document so that someone can repeat what you have done without useless content
- Make the documents clean and professional
- Typed or voice-to-text for working notes
- Check your excel documents before submitting them
- Email TA Long (cslong42) with any questions or issues

Objective:

1) *Measure DC voltage, resistance, capacitance, and current with a RMS multimeter*
2) *Learn to read resistance code charts to determine calculated resistance values then compare with readings from multimeter*
3) *Construct analog circuits*
4) *Measure a (v-t) time response curve for an RC circuit with DC voltage*

Variables:

- Independent: Power source voltage, individual resistor resistances, capacitance
- Dependent: Voltage reading when testing voltages across various points, current reading through a point, time to full charge of capacitor

Assumptions/Side Notes

- Assumptions: Resistance in wires is negligible, power source and multimeter readings are within bounds specified by manufacturer.
- The metal wire on 4 resistors broke. This was reported to the GTAs.

Sources of Uncertainty:

DC Volts		
Range	**Resolution**	**Accuracy (% rdg + digits)**
400mV	0.1 mV	±(0.3% rdg+5d)
4V	1 mV	±(0.3% rdg+2d)
40V	10 mV	±(0.3% rdg+2d)

DC Current		
Range	**Resolution**	**Accuracy (% rdg + digits)**
4 ma	1 µ	±(0.8% rdg+5d)

Good Working Notes

-Shows objective

-Relevant details

Good W.N. cont

Benginning:

We first listened to the graduate TAs about lab safety and what supplies we would need for the challenge. We proceeded to gather the breadbox, resistors, multimeter leads, manual, and wires. Note: for calculated voltage, current, and time values, see "Calculations" page photos. See "Challenge 2 Preparation Notes" to see derived equations for all calculations. Note that the calculated values on the Challenge 2 Prep pages are based on the nominal resistances, whereas the values on the Calculations pages use measured resistances as instructed. As instructed, we made effort use the highest resolution available from the multimeter for each calculation by adjusting the meter to the smallest possible range.

Activity 1:

Using color codes, we determined **R1=10.0±0.5 k-ohms, R2=100.±5 k-ohms, R3=47±2 k-ohms.** Note for R3, we rounded the uncertainty to 1 significant figure per what we learned in Physics lab. See Challenge 2 Preparation Notes for calculation.

Then we began to setup the breadbox, and plug in the leads to the meter. We connected our power supply to the breadbox red-red, and black to blue (Please see picture …). Note that we checked the "zero" of the multimeter reading the voltage value with the probe tips touched together. The multimeter read 0.000 V as expected. After setting up the connections to the board we constructed the circuit for activity 1. As a general rule, we took turns taking measurements of resistors in parallel and in series. However, sometimes one of us would take a few measurements in a row to speed up the process. For the resistance and voltage measurements in activity one we put the multimeter parallel to the circuit with units in kilo-ohms. For the current measurements the multimeter was put in series with the circuit. See Excel sheet for values.

Activity 2:

We then moved on to the Wheatstone Bridge circuit. To see the final circuit and measurements please refer to the challenge photos. We put two ten kilo-ohm resistors in

Good W.N. cont

Results, Discussion:

For Activity 1, we obtained Rac=41.4 k-ohms and Rbc=31.5 k-ohms for both the measured and calculated values. We obtained Vab=1.4 V (calculated) and 1.440 V (measured), Vbc=4.6 V (calculated) and 4.59 V (measured), and current(node a)=0.15 mA (calculated) and 0.144 mA (measured). We are satisfied with the closeness of these measurements. One thing interesting to note is that direct measurement provides a higher resolution that the calculation method, as the calculation method requires rounding to 2 significant figures due to the power supply uncertainty.

For Activity 2, we obtained a voltage value nearly equal to zero for Q1, which is consistent with the expected value from a balanced Wheatstone Bridge. For Q2, we obtained a calculated voltage of -0.15 V and a measured voltage of -0.159 V. The slight discrepancy could be due to resistances in the wires, loose connections, etc. The negative sign is a result which way we chose to orient the probes (V=Vc-Vb by our method).

For Activity 3, we considered the time to full charge the time at which the voltage of the capacitor equals 98% that of the source voltage (4.0V). This is because the capacitor will never truly "fully charge" due to the exponential charging behavior. 98% full charge occurs when Vcap equals 3.92 V, which occurs at **t=270 seconds=4.5 minutes** for both trials (note trial 2 has some time interval error – see Excel sheet). According to the article "RC Charging Circuits" on the Electronics Tutorials website, 98% full charge should occur at 4*T. T=RC=46.3 seconds => 4T=3.09 minutes. Also according to this website, "full charge" occurs at 5T=3.85 minutes. If we

were to consider "full charge" when Vc=99% Vs, our data would indicate a time to full charge equal to 6 minutes. There appears to be a large discrepancy here. However, we believe it is reasonable to compare our value with 5T, since we can see from the graph that the voltage levels out after reaching 98%*Vs. If we compare our result of t=4.5 minutes with 5T=3.85 minutes, our answer is close to what we expected. Possible causes of error: Resistances in wires, capacitor was well-used.

Sources:

- Figliola, R. S., and Donald E. Beasley. *Theory and Design for Mechanical Measurements*. 6th ed., John Wiley & Sons, 2015.
- Pardue, Sally. Dr. *ME 3023 Challenge 2*. iLearn. N/A., Dr. Sally Pardue. Web. September 12th, 2019. https://elearn.tntech.edu/d2l/le/content/7732605/viewContent/59442956/View
- N/A. *MASTECH: Bench Multimeter Users Manual*. iLearn. N/A., Dr. Sally Pardue. Web. September 12th, 2019. https://elearn.tntech.edu/d2l/le/content/7732605/viewContent/59443023/View